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PRODUCTION OF FERROAN ANDESITES BY THE EXPERIMENTAL PARTIAL MELTING OF AN LL CHONDRITE; J.C. McGuire, SUNY Stony Brook, Stony Brook NY 11794; A.J.G. Jurewicz, LESC C23, 2400 NASA Rd. 1, Houston TX 77058; and J.H. Jones, SN4 NASA/JSC, Houston TX 77058.

A partial melting experiment on the St. Severin (LL) chondrite produced a melt that was andesitic, having 54-60 wt% silica, at 1200°C and an oxygen fugacity (fO_2) of IW+2, two log units above the iron-wüstite (IW) buffer *[1]*. Under these same conditions, CV, CM and L chondrites produced low-silica melts (~40 wt% silica) resembling angrites *[1,2]*. This experimental study attempts to reproduce and explain this unusual result.

INTRODUCTION: Previous studies have shown that, depending upon the oxygen fugacity, partial melts of CV, CM and H chondritic meteorites resemble either angrites or eucrites, two types of meteoric basalts *[2,3]*. The fO_2 controls the silicate phase equilibria indirectly by changing the FeO/Fe^0 ratio of the iron in system. For volatile-free CV, CM and H chondrites, partial melts produced at IW+2 (where there is no Fe^0) were low in silica (~40%), and resemble angritic meteorites. Conversely, the melts formed at IW-1 (where there is 2-7 wt% Fe^0) were higher in silica (~48-50 wt%) and resemble eucrites (Fig. 1). In sharp contrast, the partial melting experiment on the St. Severin (LL) chondrite run at 1200°C and IW+2 produced melts unlike any other. It did not resemble any known meteorite, being *much* too siliceous (~54-60 wt%). This study investigates this unusual result.

METHODS: Two starting materials were used: 1) a powder of actual St. Severin silicate (courtesy of E. Jarosewich, Smithsonian Institution) to which powders of iron and nickel metal were added to duplicate the bulk meteorite composition *[4]*, and 2) a synthetic, partially-glassed St. Severin simulant. The simulant was used in all experiments to conserve the real St. Severin; however, charges of the natural St. Severin were run with the simulant in the 1200°, 1150°, and 1120°C experiments. This duplication ensured that the simulant accurately reproduced the St. Severin phase equilibria, especially at low temperatures.

Experiments were conducted by placing pressed-pellets of starting materials in a reusable platinum basket which was then hung in a vertical, controlled-atmosphere furnace. The basket was saturated from previous use, so that negligible iron was lost from the samples *[2,3]*. The oxygen fugacity (IW+2) was controlled by a flowing mixture of CO and CO_2 *[5,6]*.The oxidation state of the mixed gas was monitored in a remote furnace using a solid electrolyte cell and oxygen as a reference gas *[6]*. It is important to note that this method of controlling fO_2 allows volatile-loss from the sample to the furnace gas.

The isothermal experiments were performed in the temperature range of 1120° to 1240°C, and lasted 4 to 7 days, with the lower-temperature experiments running for longer durations. One additional experiment, specifically designed to test the effect of sodium on the phase equilibria, ran for 2 days at IW-1 and 1300°C to volatilize Na_2O, and then ran isothermally at IW+2 and 1210°C to re-equilibrate the charge. To minimize quench effects, samples were drop-quenched into de-ionized H_2O. After sectioning, mounting and polishing, identification of phases and broad observations were made using a JEOL scanning electron microscope. A Cameca electron microprobe was used for compositional analyses at 15kV and 30 nA. Several examples of each phase were analyzed at points ~10 microns from phase boundaries to minimize fluorescence and quench effects.

RESULTS: All isothermal charges contained a high silica melt (54-60 wt% SiO_2), olivine (65-69 m% Fo), and low-calcium pyroxene (62-70 m% En; 2-10 m% Wo), as well as minor chromite and Fe-Ni sulfide. In addition, a high-calcium pyroxene (46 m% En; 44 m% Wo) was found in the 1120°C charge. Plagioclase was not observed.

Equilibrium was evaluated in several ways. For example, Fe/Mg olivine/melt distribution coefficients ($^{ol/melt}K_{DFe/Mg}$) ranged from 0.32 to 0.36, in good agreement with the values obtained for other experiments having similar phase equilibria *[2,3,7]*. Similarly, mass balances reproduced the starting compositions and calculated consistent phase abundances, suggesting that the measured compositions were representative [Fig. 2].

The extremely high silica contents and the major element ratios of the melts from the isothermal experiments differ significantly from the IW+2 melts of other meteorites, as shown by their CIPW norms [cf., Fig. 1]. Additionally, the St. Severin phase assemblages consist of a high-silica melt coexisting with equilibrium olivine, pyroxene (both with low CaO contents), and chromite; whereas other chondritic IW+2 melts coexist with olivine and pyroxene (both with higher CaO contents), and hercynitic spinel. In terms of the silica content, the volatile-rich St. Severin melts can best be compared to ferroan andesites, whereas melts from other chondritic IW+2 melts look more like angrites. In fact, the volatile-rich St. Severin melts are higher in silica than the partial melts of H, CM, and CV chondrites produced at IW-1 *[2,3,8 and Table 1]*.

One experiment was performed in which a St. Severin charge was pre-processed at IW-1 in order to remove the 1-3 wt% sodium that persisted in the melts of charges from the other experiments. After sodium had been volatilized, the melt produced was ~7 wt% lower in silica [Table 1]; however, this melt was still much more siliceous than IW+2 melts from other types of chondrites. Moreover, the silica content of this melt resembled those from other chondrites run at IW-1, and the equilibrium phase assemblage contained low-calcium pyroxene and chromite rather than hercynitic spinel.

DISCUSSION: Partial melts of St. Severin differ from IW+2 melts observed in charges from other meteorites melted under the same conditions in two ways. First, at the high fO_2, it is (kinetically) difficult to devolatilize the sodium from the melt and -- as the experiment in which the charge was subjected to a pre-processing showed -- the residual Na_2O is partially responsible for the high silica content of the melts. This is consistent with the observations of *[9]* on the effect of Na_2O on the forsterite-protoenstatite boundary. A comparison of phase abundances calculated for the volatile-rich and volatile-free charges shows that there is a decrease in the percentage of pyroxene present. However, pyroxene alone would not have enough silica to account for the very high silica; plagioclase is the only solidus phase that could account for up to 60 wt% SiO_2 in the melt.

Still, even the sodium-free St. Severin charge contains a siliceous melt and a phase assemblage unlike that observed in the CV, CM, and H chondrites at IW+2, but more like that observed at IW-1 (~49 wt% SiO_2). Again, fO_2 affects the silicate phase equilibria in the H, CV, and CM chondrites indirectly: when the fO_2 is changed from IW-1 to IW+2, metal is oxidized. The FeO and NiO from the metal effects the silicate phase equilibria. If enough metal is oxidized, hercynitic spinel is stabilized, and the melts produced are silica-poor (~40 wt% SiO_2) *[2,3]*. But St. Severin has an intrinsically low Fe/Si ratio, so the melting relations don't shift even after all its iron is FeO. Therefore, the high-iron phase assemblages seen in charges of other chondrites melted at IW+2 can not be produced, and the melting relations in the bulk St. Severin resembles that of other chondrites at IW-1.

REFERENCES: *[1]* Egon Weber (1992) *LPI 8th Annual Summer Intern Conf. [abst.]* 31-33; *[2]* Jurewicz *et al.* (1991) *Sci.* **252** 695-698; *[3]* Jurewicz *et al.* (1993) *Geochim. Cosmochim. Acta* **75** 2123-2139; *[4]* Jarosewich (1990) *Meteoritics* **25** 323-337; *[5]* Deines *et al.* (1974) *Bull. Earth Mineral Sci. Exp. Sta.* **88** 129p; *[6]* Jurewicz *et al.* (1993) *NASA Tech. Memo.* **104774** 37p.; *[7]* Stolper (1977) *Geochim. Cosmochim. Acta* **41** 587-611; *[8]* Jurewicz *et al* (1994) *Lun. Planet. Sci. Conf.* XXV this volume; [9] Kushiro (1975) *Am. J. Sci.* **275** 411-431

Table 1. St. Severin (LL) partial melts produced with and without preprocessing at IW+2, and at IW-1. Melts of Lost City (H) *[1,8]* are given for comparison.

	St. Severin			Lost City	
	High Na_2O	Low Na_2O			
fO_2	IW+2	IW+2	IW-1	IW-1	IW+2
T(°C)	1200	1210	1200	1200	1200
SiO_2	57.4	50.6	50.7	50.8	40.2
TiO_2	0.31	0.38	0.47	0.40	0.50
Al_2O_3	10.2	9.96	13.0	11.1	11.9
FeO*	16.2	21.9	17.8	22.0	28.9
MnO	0.26	0.28	0.32	0.29	0.26
MgO	6.22	7.67	7.31	6.85	5.48
CaO	6.91	7.92	8.39	8.11	10.9
Na_2O	2.20	0.31	0.69	0.33	0.49
NiO	0.07	0.18	0.04	0.06	0.31
Total	100.3	99.3	99.3	100.0	99.8

* all iron as FeO.

Figure 1. Comparison of CIPW norms from St. Severin IW+2 partial melts*[this study]*, with those of CM, CV, and H chondrites at IW+2 and IW-1 *[cf., 1,2,3,8]*, as well as eucrites and angrites.

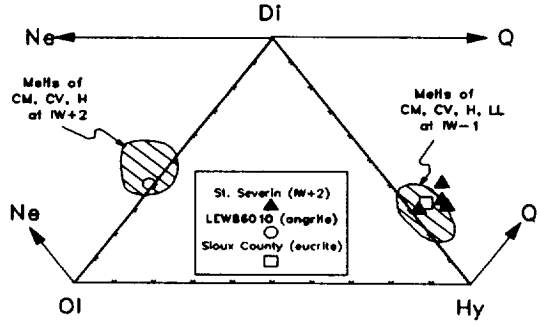

Figure 2. Abundance of silicate phases as a function of temperature. Minor chromite and sulfide are also present. Note: olivine and pyroxene define a peritectic. Symbols: Open is simulant; solid is St. Severin.